APPENDIX E

Road Assessment Method

Forest Road Sediment Assessment Method (FRoSAM)

Introduction

Section 303 of the Clean Water Act requires the identification of all impaired waterbodies in the United States. Once identified, the Clean Water Act further requires the establishment of a maximum pollutant load that can be assimilated by a given impaired waterbody and the implementation of an explicit plan to stay below that maximum. The water quality improvement plans that are developed to meet these requirements are known as TMDLs (Total Maximum Daily Load).

The development of TMDLs for waterbodies impaired by siltation has become one of the major challenges for states that have substantial numbers of watersheds with agriculture and timber harvest as the dominant land uses. The challenge has two facets: first, an accurate assessment of the existing sources of siltation must be conducted and second, an accurate measure of any improvements must be made.

In most of the managed forested watersheds in the Western United States, forest roads are frequently one of the largest sources of non-point source pollution. The following discussion presents a practical approach for quantifying sediment load from forest roads as well as predicting and measuring improvements made during TMDL implementation.

The assessment method presented here is a refinement of the methods developed by the Washington Forest Practices Board (WFPB, 1997), which is essentially an accounting procedure involving field observations of erosion and sediment delivery to streams. Streams are defined as "any drainage depression containing a defined bed and banks extending continuously below the drainage site. Flow regime can be ephemeral, intermittent, or perennial" (WFPB, 1997). Therefore, erosion that is delivered to a drainage feature known to be discontinuous below (i.e. the flow goes subsurface and does not deliver to fish-bearing waters) should not be counted into the sediment load calculation.

Methods

Step 1: Measure Source Area

The source area for sediment load quantification encompasses all areas of road tread, ditches, cut slope, and fill slope from which water could flow to a stream. As an example in determining sediment load, suppose water flow over a road tread and cut slope is diverted by a drain-dip 100 feet from a stream crossing, and then passes into a heavily vegetated, flat area that precludes overland flow from reaching the stream. The area uphill of the drain-dip would not be counted into the sediment load to the stream, since the drain-dip serves to isolate it from the stream.

The length (longitudinally along the road) and width (across the road prism) of the tread, cut slope and fill slope are measured to derive the total areal extent (acres) of source area. If the cut

and fill slopes vary significantly in width along a reach of road, the observer must estimate an average width of those features.

Step 2: Apply Modifying Factors

Several modifying factors which are described below and summarized in **Table E-1** are applied to the measurement of actual eroding surface area. These are applied as average factors over each individual eroding area.

Cover Factor
The cover factor is the percent of non-erodible cover on each of three road features: tread, cut slope, and fill slope. Cover percent translates into the modifying factors shown in **Table E-2** (Burroughs and King, 1989).

Gravel Factor
The gravel factor accounts for reduced erosion from roads that have gravel applications. With a gravel lift of 2 to 6 inches in depth, the factor is 0.50. With a gravel lift of greater than 6 inches, the factor is 0.20 (WFPB, 1997).

Percent Delivery
The determination of the percent of eroded fine sediment delivered to a stream is perhaps the most challenging part of this assessment methodology. This factor must take into account the observer's sense of sediment delivery over time and, without an accurate way to characterize historical or potential future sedimentation, it becomes a matter of professional judgment.

Another difficulty in establishing sediment delivery is the potential for "double mitigation". For example, the calculated amount of sediment generated at a given location would be overly reduced if the gravel factor was applied as well as claiming that the delivery was very low due to the lack of sediment generation. This would result in a double mitigation for gravel. The amount of fine sediment *generated* and the amount of fine sediment *delivered* are two different factors. To avoid this pitfall, consider "delivery" as the *potential* for sediment to be carried to a stream once it is eroded. If there is no sediment being eroded, take that into account with the modifying factors of cover, gravel, etc. **Table E-3** describes the categories of sediment delivery to streams. These can be adjusted based on the experience and judgment of the observer.

Step 3: Calculate Road Sediment Load

To calculate the volume of sediment contribution from each road location, take the following steps:

1. Assign a base (natural) erosion rate from roads in tons/acre/year. This can be derived from a combination of published values and professional knowledge of the soils in the watershed. Erosion rates from forest roads have been calculated for a number of regions of the country including the following:

    - Appalachia (Swift, 1984; Kochenderfer and Helvey, 1984, 1987),

- Pacific Northwest (Reid and Dunne, 1984; Bilby et al., 1989),
- Intermountain West (Megahan and Kidd, 1972; Burroughs and King, 1989).

2. Calculate the area of erosion (length times width) for the tread, cut and fill slopes, and convert it to acres.
3. Apply each modifying factor: cover, gravel, traffic, snow (applied to traffic factor directly), and percent delivery.
4. Multiply all of these together to derive the sediment volume from each of these road features (road tread, cut slope and fill slope) individually.
5. Sum these three values for the total delivery for that location, which will yield a figure in tons of sediment per year.

Location totals thus derived can be summed for the entire watershed to arrive at a total fine sediment contribution from roads.

Step 4. Calculate the Natural Rates of Sedimentation

A critical piece of information in the development of a TMDL is the comparison of the study area's current sediment load to naturally occurring conditions. Two methods that have been used successfully (MDEQ, 2003; Land & Water Consulting, 2001; Plum Creek Timber Company, 1998) to determine natural rates of erosion are described below. Depending on available data, more reliable methods may be derived.

Soil Creep Estimate
Soil creep is the slow downhill movement of the soil mantle that results from disturbance of the soil by freeze/thaw processes, wetting or drying, or plastic deformation under the soil's own weight (Dunne and Leopold, 1977). Other soil displacing processes such as tree throw and biological activity are typically included in estimates of soil creep.

Erosion rates from soil creep are calculated using the following equation:

$$\text{Annual Erosion Volume } (m^3/yr) = (L*2) * D * C$$

Where:

L = length of stream channel in meters (doubled to account for both sides of stream).
D =soil depth in meters.
C =creep rate in meters per year.

Measured soil creep rates typically range from 0.001 to 0.002 meters per year in the United States (Sanders and Young, 1983). A creep rate of 0.001 meters per year for basins with an average slope of less than 35%, and 0.002 m/yr for basins with average slope of greater than 35% is assigned (WFPB, 1997). Stream length may be determined by planimeter or GIS, if available. Soil depth information is often available from a local USDA office or other government office depending on the location. As many soils inventories provide erosion rates for a combination of both coarse and fine sediment, one must apply a factor to determine the percent fines in the study area's soil types.

Landtype Estimate

When working in watersheds that have a substantial proportion of land in a National Forest, a catalog of landtypes may be available from the Forest Service. Estimates of erosion rates for each landtype have been determined by Forest Soil Scientists. A watershed erosion rate may be calculated as a weighted average by area of landtype. This may be done manually with a planimeter or with GIS.

The values of natural background sedimentation can then be compared to road sedimentation to determine the percentage of total sediment load that is coming from forest roads.

Summary

Using this assessment methodology, land managers can more efficiently focus their restoration budget and can document watershed improvements in a consistent, quantitative manner. Road segments that are significant sediment sources can be ranked, allowing for easy prioritization of restoration needs. With this information the land manager can plan for road upgrades, sediment mitigation, or road obliteration and can credibly document those reductions in sediment load.

Table E-1. Factors Applied in Forest Road Surface Sediment Assessment.

Factor	Definition
Cover	Percent of non-soil cover.
Gravel	A categorical factor accounting for mitigating that results in gravel road surfacing.
Delivery	Percent of displaced fine sediment which is delivered into a waterbody.

Table E-2. Factor for Percent Cover Values.

Cover Percent	Factor
>80%	0.18
50%	0.37
30%	0.53
20%	0.63
10%	0.77
0%	1.00

Table E-3. Categories of Sediment Delivery to Streams.

Percent Category	Description

100%	Chronic direct delivery under most erosional scenarios.
75%	Direct delivery evident but not chronic; effective buffer (provided by distance, gentle topography, or vegetation) during low intensity erosional events.
50%	Direct sediment delivery, but minor amounts or older events.
25%	Direct delivery unlikely except in moderate to major erosional events.
5%	Effective buffer, but proximity of road to stream makes 5% necessary.

Forest Road Sediment Assessment Method
C.P. Callahan